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IMPORTANCE OF NANOTECHNOLOGY IN AGRICULTURAL AND SOCIO-ECONOMIC ISSUES OF NANOTECHNOLOGY

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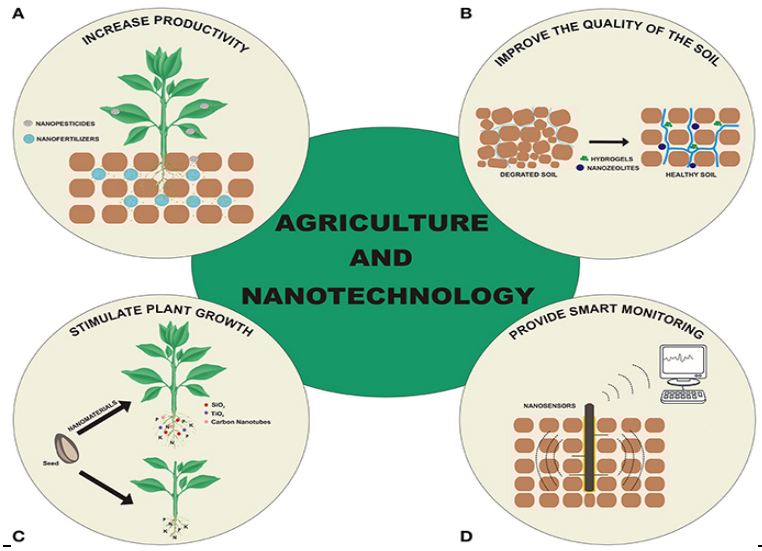
Agriculture is the backbone of most of the developing countries in which a major part of their income comes from agriculture sector and more than half of the population depends on it for their livelihood. The current global population is nearly 6 billion with 50% living in Asia. A large proportion of those livings in developing countries face daily food shortages as a result of environmental impacts or political instability, while in the developed world there is a food surplus. For developing countries, the drive is to develop drought and pest resistant crops which also maximize yield. In developed countries, the food industry is driven by consumer demand which is currently for fresher and healthier foodstuffs (Anonymous, 2009).

Agriculture and Nanotechnology

In the agricultural sector, nanotech research and development is likely to facilitate and frame the next stage of development of genetically modified crops, animal production inputs, chemical pesticides and precision farming techniques. The use of nanotechnology in agriculture has been mostly theoretical but it has begun and will continue to have a significant effect in the main areas of the food industry development of new functional materials, product development and design of methods and instrumentation for food safety and bio-security (Joseph and Morrison, 2006). Recent advances in materials science and chemistry have produced mastery in nano particle technology, with wide ramifications in the field of agriculture. One area in particular is that of the cotton industry where current techniques of spinning cotton are quite wasteful. From harvesting the cotton to finalizing the fabric it's made into, over 25% of the cotton fibre is lost to scrap or waste (Kumar, 2009).



Application of Nanotechnology in Agriculture

1. The application of nanomaterials (Nanomaterials and nanostructures with unique chemical, physical, and mechanical properties – e.g.

electrochemically active carbon nanotubes, nanofibers and fullerenes – have been recently developed and applied for highly sensitive bio-chemical sensors. These nanosensors have also relevant implications for application in agriculture, in particular for soil analysis, easy bio-chemical sensing and control, water management and delivery, pesticide and nutrient delivery.) in agriculture aims in particular to reduce applications of plant protection products, minimize nutrient losses in fertilization, and increase yields through optimized nutrient management.

2. Nanotechnology devices and tools, like nanocapsules, nanoparticles and even viral capsids, are examples of uses for the detection and treatment of diseases, the enhancement of nutrients absorption by plants, the delivery of active ingredients to specific sites and water treatment processes.
3. The use of target-specific nanoparticles can reduce the damage to non-target plant tissues and the amount of chemicals released into the environment.
4. Nanotechnology derived devices are also explored in the field of plant breeding and genetic transformation.
5. Nanotechnology is considered as one of the possible solutions to problems in food and agriculture. Just like biotechnology, issues of safety on health, biodiversity, and environment along with appropriate regulation are raised on nanotechnology.

Areas of Nanoscience Research in Agriculture and Food Science

1. Food safety and biosecurity
2. Material science Food processing and
3. Product development

Importance of Nanoparticles in Agriculture

Nano Silver: Nano silver is the most studied and utilized nano particle for bio-system. Antifungal effectiveness of colloidal nano silver (1.5 nm average diameter) solution, against rose powdery mildew caused by *Sphaerotheca pannosa* Var *rosae*. It eliminates unwanted microorganisms in planter soils and hydroponics systems. It is being used as foliar spray to stop fungi, moulds, rot and several other plant diseases.

Nano Alumino-Silicate: The advantage is that alumino-silicate nanotubes sprayed on plant surfaces are easily picked up in insect hairs. Insects actively groom and consume pesticide-filled nanotubes. They are biologically more active and relatively more environmentally-safe pesticides.

Titanium Dioxide (TiO_2) Nanoparticles: Titanium dioxide (TiO2) is a non-toxic white pigment widely used in the manufacture of paints, study, ink, cosmetics, ceramics, leather, etc. and is a very strong disinfectant as compared to chlorine and ozone. Since TiO2 is harmless, it is approved for use in food products upto 1% of product final weight. Scientists

have been trying to improve the phytopathogenic disinfection efficiency of TiO2 thin films by dye doping and other suitable methods (Yao *et al*., 2009).

Carbon Nanomaterials: Among the various engineered nanomaterials, carbon based nanomaterials (such as single walled carbon nanotubes (SWCNTs), multi walled carbon nanotubes (MWCNTs), buckyballs, graphene, etc.), occupy a prominent position in various nano-biotechnology applications.

Magnetic Nanoparticles: The scope of magnetic nanoparticles for site-targeted delivery of drugs has been exploited widely in biomedicine for the treatment of various diseases (Mornet *et al.,* 2004; Jurgons *et al*., 2006).

Socio-Economic Issues of Agricultural Nanotechnology

The emergence of nanotechnology applications in consumer products has also raised a number of ethical and societal concerns in some countries, starting from health and environmental safety, to consumer perception and intellectual property rights. From different studies about consumer acceptance of nanotechnology products, it appears that the public opinion is generally not negative. The public seems to be unconcerned about many applications of nanotechnology with the exception of areas where societal concern already exists such as pesticides. As for many emerging technologies, intellectual property in nanotechnology, and in particular freedom to operate, constitute relevant issues for the development of new products. The number of patent applications in nanotechnology has increased more than tenfold during the last 20 years, demonstrating a great potential for commercial applications.

In developing countries nanotechnologies can have important applications in several agri-food areas, such as food security, input delivery, rice production systems, agri-biotechnology, healthcare of animals, precision farming, food industry and water use.

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